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Marie-Hélène Broihanne, Maxime Merli, Patrick Roger

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Faculté des
sciences économiques
et de gestion

PEGE
61, avenue de la Forêt Noire
67085 STRASBOURG Cedex
Tél. : (33) 03 90 24 21 52
Fax : (33) 03 90 24 21 51
www-ulp.u-strasbg.fr/large

Institut d'Etudes Politiques
47, avenue de la Forêt Noire
67082 STRASBOURG Cedex

A BEHAVIOURAL APPROACH TO FINANCIAL PUZZLES

Marie-Hélène BROIHANNE, Maxime MERLI, Patrick ROGER

LARGE, Université de Strasbourg.

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ABSTRACT

Many financial puzzles have been solved, at least partially, by the introduction of alternative assumptions on the behaviour of investors. Cumulative prospect theory and mental accounting are two such approaches which are used in this paper to analyze some of the most important financial puzzles. We first focus our attention on anomalies (or considered as such in the standard expected utility model) at the individual level, for example the disposition effect or the low diversification puzzle. We then address two aggregate puzzles, namely the equity premium puzzle and the return predictability puzzle. We show how recent behavioral models allow to explain these anomalies in a very natural way.

INTRODUCTION

About ten years ago, Richard Thaler started a chronicle in the *Journal of Economic Perspectives* entitled "Anomalies"[1]. Several authors contributed to this series of papers and presented a number of phenomena that are not easily explainable in the standard framework of the Expected Utility Theory.

Behavioural finance is a rapidly growing strand of research whose roots can be found in the numerous anomalies put to light, either in the observed behaviour of investors, or in the dynamics of market prices.

Beyond the empirical evidence, new theoretical models have developed to take into account the behavioural biases of investors and to analyse their consequences on prices.

As for every "young" theory, models are burgeoning in the literature and, at the moment, nobody can predict the future of all these contributions. However, it seems that some of them are becoming « standard ». It is the case for cumulative prospect theory, even if many

[1] As more than one hundred references are quoted in the text, we do not provide the precise references in this introduction

discussions still arise about the shape of the value function or of the probability weighting function.

The idea of mental accounting is also relevant as a convenient way to address many anomalies that cannot be explained by the perfect rationality assumption.

In the present paper we want to build on these two blocks, prospect theory and mental accounting, to illustrate how some important financial puzzles can be addressed in a satisfactory way.

The paper is organized as follows.

Section 1 first presents cumulative prospect theory and focuses on the specific features of this model when compared to the standard expected utility model. We also discuss briefly the abovementioned problems linked to the choice of the value function and to the probability weighting function. In the second part of section 1, we define mental accounting and analyze the three main components of this cognitive process. First, the question of the framing of outcomes is addressed, leading us to present the idea that the marginal propensity to spend money depends on its origin and on the mental account in which it is stored. The second dimension of mental accounting deals with the frequency at which mental accounts are evaluated. It has non negligible consequences on buying and selling decisions and on portfolio choice (especially in terms of diversification). Finally, the concept of mental accounting leads to a critical look on the usual mean-variance portfolio theory. Moreover, a long standing puzzle like the dividend puzzle finds a very simple justification if investors manage different mental accounts.

Section 2 addresses two puzzles concerning the behaviour of investors (individual or professionals). The first one is the disposition effect, which is the tendency to sell winning stocks too early and to hold on to losers too long. We first present the theoretical justifications found in the literature… and also some controversial results about the existence of this effect. We then review the important empirical and experimental literature illustrating the disposition effect in different contexts or diverse populations of investors.

The second anomaly presented in this section relies on the general principle of diversification. Under-diversification and non participation to the stock market are two well documented phenomena in contradiction with either Markowitz portfolio theory or the Capital Asset Pricing Model. We analyze the theoretical justifications of these biases in the light of behavioural models proposed by Nicholas Barberis and some of his co-authors a few years ago. The corresponding empirical evidence is then briefly reviewed.

Section 3 deals with two well-known aggregate puzzles. The first one, possibly the most popular, is the equity premium puzzle. We show how the combination of prospect theory and mental accounting solves the puzzle and some other neighbour problems like the risk-free rate puzzle or the low correlation between consumption growth and stock returns. Obviously many theories have been proposed to solve this enigma and we only consider here the “behavioural ones”. Our purpose is to show that simple and intuitive approaches can sometimes explain multi-dimensional and complex phenomena.

The second part of section 3 is devoted to the predictability of returns, an important subject after more than thirty years of preponderance of the Efficient Markets Hypothesis. Predictability of returns is presented through the lens of the momentum effect and of the post-earning announcement drift. Roughly speaking, behavioural biases like the disposition effect induce distortions in demand functions which in turn lead to some reversion to the mean for stock prices. However, inefficiencies like “some predictability” do not mean the presence of arbitrage opportunities. Especially, as far as stocks are concerned, reversion to the mean is not an insurance to realize profits. It only changes the probability distribution of gains.

The paper ends by a short conclusion.

1 / Prospect theory and Mental accounting

In this section we first introduce the main features of prospect theory and compare it with the standard expected utility model. We then describe the cognitive process called mental accounting and its implications on the behaviour of investors.

1.1 Propect theory

Prospect theory is an alternative model of decision making under risk developed by Kahneman and Tversky (1979) and refined by Tversky and Kahneman (1992). The latter version is called cumulative prospect theory. It allows to take into account many experimental observations not compatible with expected utility theory.

Let $x = ((x_i, p_i), i = 1,...,n)$ denote a lottery where x_i is the *i*-th outcome and p_i the corresponding probability of occurrence. Consider an agent endowed with an initial wealth *W* and a concave utility function *U*. He evaluates the opportunity to play the lottery *x* by computing:

$$E\left[U(W+x)\right] = \sum_{i=1}^{n} p_i U(W + x_i)$$

In other words, the expected utility of *W*+*x* is a weighted average of the utilities associated to the final wealth levels that can be reached when playing the lottery.

Cumulative Prospect Theory[2] (CPT in the following) differs from Expected Utility Theory (EUT) in at least three ways:

- utility is derived from changes in wealth, relative to a reference point with respect to which gains and losses are defined. Losses are weighted more heavily than gains, this feature being referred to as loss-aversion ;
- agents are risk-averse in the region of gains but risk seeking in the region of losses ;
- individuals use decision weights instead of probabilities and overweight low probabilities of extreme events. This feature captures the empirical evidence that many economic agents simultaneously demand lottery tickets and insurance contracts.

Under CPT preferences, a lottery $x = ((x_i, p_i), i = 1,...,n)$ is evaluated through a valuation function $V(x)$ defined as follows:

$$V(x) = V(x^+) + V(x^-) = \sum_{i=m+1}^{n} \pi_i^+ v(x_i) + \sum_{i=1}^{m} \pi_i^- v(x_i)$$

where $x^+ = \max(0, x)$; $x^- = -\max(0, -x)$. This way of writing the evaluation function means that *x* is defined in terms of net gains and losses with respect to a reference point and that the outcomes of the lottery are assumed to be ranked in increasing order. They are divided into two categories: the *m* first outcomes are negative (losses) and the *n-m* following ones are positive (gains). The evaluation function is defined over these two domains with different decisions weights π_i and a specific value function $v(.)$.

The value function is analogous to the utility function of EUT but is defined differently over gains and losses. The standard formulation of the valuation function is the following:

$$v(y) = \begin{cases} y^{\alpha} & \text{if } y \geq 0 \\ -\lambda y^{\beta} & \phantom{\text{if }} y < 0 \end{cases} \tag{1}$$

[2] Kahneman and Tversky (1979), Tversky and Kahneman (1992)

with λ >1 (loss aversion) and $0 < \alpha, \beta \leq 1$ (diminishing sensitivity). The value function (see figure 1) is concave on gains, convex on losses, and kinked at 0, due to the loss aversion coefficient λ.

The probabilities associated to the gamble's outcomes are weighted by a non-linear function $w(.)$ which is defined separately on the cumulative probability distribution[3] of gains and losses.

$$\pi_1^- = w^-(p_1)$$

$$\pi_i^- = w^-(F_x(x_i)) - w^-(F_x(x_{i-1})) = w^-(\sum_{j=1}^{i} p_j) - w^-(\sum_{j=1}^{i-1} p_j) \quad for\ 2 \leq i \leq m$$

$$\pi_n^+ = w^+(p_n)$$

$$\pi_i^+ = w^+(1 - F_x(x_{i-1})) - w^+(1 - F_x(x_i)) = w^+(\sum_{j=i}^{n} p_j) - w^+(\sum_{j=i+1}^{n} p_j) \quad for\ m \leq i < n$$

The probability weighting function put forward in the literature is generally inverse S-shaped (see figure 2).

The curvature of the value function together with a typical non-linear transformation of probabilities suggest a fourfold pattern of risk attitude, whereby the representative agent is risk averse for large-probability gains and small-probability losses, but risk-loving for small-probability gains and large-probability losses. This creates a richer pattern of attitudes toward risk, compared with EUT which assumes risk aversion everywhere.

As an example, consider an investor's decision at date *t*=0. Suppose that this investor has the opportunity to buy a 100€ stock in order to sell it at date *t*=1. According to the predictions of a given analyst, the distribution of the future stock price is given in table 1.

Probability	Stock price (t=1)
0,05	90
0,05	100
0,10	130
0,35	82
0,45	110

Table 1: Stock price distribution

[3] F_x is the cumulative distribution function of the lottery *x*.

To evaluate this investment decision, the investor uses CPT and first computes the value function as given in table 2. In this table, the first two columns rank the final outcomes in increasing order and net gains/losses[4] appear in column 3. The value function is computed in column 4 with common values of parameters, λ=2,25 and $\alpha = \beta = 0,88$ (estimations of Tversky and Kahneman, 1992). For example, $-28,630 = -2,25 \times \left(18^{0,88}\right)$ and $7,586 = 10^{0,88}$.

Probability	**Final wealth**	**Gain/loss**	**Value function v(.)**
0,35	82	-18	-28,630
0,05	90	-10	-17,068
0,05	100	0	0,000
0,45	110	10	7,586
0,1	130	30	19,947

Table 2: Computation of the value function

The decision weights are computed in table 3 with the probability weighting functions suggested by Tversky and Kahneman (1992):

$$w^{-}(p) = \frac{p^{\delta^{-}}}{\left(p^{\delta^{-}} + (1-p)^{\delta^{-}}\right)^{1/\delta^{-}}} \text{ and } w^{+}(p) = \frac{p^{\delta^{+}}}{\left(p^{\delta^{+}} + (1-p)^{\delta^{+}}\right)^{1/\delta^{+}}}$$

with parameter values δ^{-}=0,69 et δ^{+}=0,61.

Probability	$w^{-}(\sum_{j=1}^{i} p_j)$	$w^{+}(1-\sum_{j=i}^{n} p_j)$	$\pi^{-}(p)$	$\pi^{+}(p)$
0,35	0,3601	1,0000	0,3601	
0,05	0,3917	0,5027	0,0316=*0,3917-0,3601*	
0,05	0,4228	0,4739		0,0272=*0,4739-0,4467*
0,45	0,7749	0,4467		0,2604=*0,4467-0,1863*
0,1	1,0000	0,1863		0,1863

Table 3: Computation of decision weights

Finally, from values in tables 2 and 3 we obtain:

[4] In the tables, lines akin to losses appear in grey. To simplify, we assume a zero risk free rate.

$$V(x) = -5{,}1566 = V(x^+) + V(x^-) = -10{,}848 + 5{,}6913$$
$$= \left[\left(-28{,}63 \times 0{,}3601\right) + \left(-17{,}068 \times 0{,}0316\right)\right] + \left[\left(0 \times 0{,}0272\right) + \left(7{,}586 \times 0{,}2604\right) + \left(19{,}947 \times 0{,}1863\right)\right]$$

If the investor was evaluating the same decision with EUT and assuming a square root utility function, he would obtain:

$$E\left[U(W+x)\right] = 10{,}003 = \left(\sqrt{82} \times 0{,}35\right) + \left(\sqrt{90} \times 0{,}05\right) + \left(\sqrt{100} \times 0{,}05\right) + \left(\sqrt{110} \times 0{,}45\right) + \left(\sqrt{130} \times 0{,}1\right)$$

As with CPT the evaluation is negative, the investor would not invest, whereas as 10,003>10, he would buy the stock in the EUT case. These conflicting results illustrate the ability of CPT to take into account investors' loss aversion in decisions. In fact, the largest possible loss is overweighed and the 10% gain is underweighted. It is worth to notice that the sum of decision weights is lower than 1.

Although CPT appears experimentally a successful theory to describe decisions under risk, the choice of the functions *v*(.) and *w*(.) has been criticized for various reasons.

First, as shown by De Giorgi, Levy and Hens (2004) and Rieger and Wang (2006), *w*(.) is not monotonic for small values of δ.

Second, the usual value function *v*(.) leads to the non existence of an equilibrium in a financial market of CPT maximizers. More precisely, De Giorgi, Levy and Hens (2004) note that an infinite prospect utility is always attainable by an agent that maximizes the piecewise power function in the absence of any borrowing constraint on his portfolio selection problem. Moreover, they also show that asset allocations are highly sensitive to changes in the value function parameters $\alpha=\beta$ and λ. They demonstrate that this problem can be solved by using exponential value functions (because these functions are bounded), for example:

$$v(x) = \begin{cases} \delta^+(1-\exp(-\alpha x)) & \text{if } x > 0 \\ -\delta^-(1-\exp(\alpha x)) & \text{elsewhere} \end{cases}$$

A third criticism is given by Köbberling and Wakker (2005). They propose an index of loss aversion which is independent of the unit of payment and which incorporates basic utility, probability weighting and the usual loss aversion coefficient. For the piecewise power value function, they show that their index of loss aversion cannot be defined when $\alpha\neq\beta$. However, this problem can also be solved by using an alternative value function.

Finally, the interplay of value and weighting functions causes problems relative to the St. Petersburg Paradox. This well known paradox is associated with the birth of EUT. Bernoulli (1738) showed that an infinite expected value lottery has a finite price if one considers the expected utility of the monetary value it delivers using a concave utility function. Blavatskyy

(2005) and Rieger and Wang (2006) show that with CPT, a gamble with finite expected value can have infinite prospect utility because one of the following effects is at stake: the slope of the value function does not decrease enough for high values and the probability weighting function of Tversky and Kahneman (1992) has an infinite slope at 0 and 1. Using different values of parameters to control for these effects (α and γ), they demonstrate that the numerical range of values that were obtained experimentally do not respect the condition $\alpha < \gamma$, and therefore gives rise to an infinite prospect utility.

De Giorgi and Hens (2006) also show that all these problems can either be resolved by using an alternative value function or a modified probability weighting function. The value function has to have a more pronounced curvature than the piecewise power function for large outcomes in order to discourage extreme risk taking. They propose a piecewise negative exponential value function that ensures existence of a CAPM equilibrium, resolves three well known financial puzzles (the equity premium, the value and the size puzzle) and is also able to explain the disposition effect. Moreover, as the piecewise negative exponential function is bounded, the St. Petersburg paradox does not arise. Rieger and Wang (2006) show that another approach to fix the problem is to work with their own alternative weighting function which exhibits a finite slope at 0.
Finally, Rieger (2007) observes that people may show a degree of risk aversion that cannot be modelled within the standard version of CPT. He demonstrates that using an exponential value function, instead of the standard one, allows to cover the whole spectrum of risk averse behaviour.

1.2 / Mental accounting

"*A few years ago, I gave a talk to a group of executives in Switzerland. After the conference my wife and I spent a week visiting the area. At the time the Swiss franc was at an all-time high relative to the US dollar, so the usual high prices in Switzerland were astronomical. My wife and I comforted ourselves that I had received a fee for a talk that would easily cover the outrageous prices for hotels and meals. Had I received the same fee a week earlier in New York though, the vacation would have been much less enjoyable.*" (R. Thaler, 1999, P. 183).

This anecdote gives a good illustration of the cognitive process called mental accounting and describes how expenditures are grouped into categories. Mental accounting can be defined as the set of cognitive operations used by individuals when they face financial decisions. More precisely, mental accounting focuses on how economic agents categorize, organize, evaluate the flow of money. The objective of this section is to highlight some crucial consequences of mental accounting[5]. Thus, we focus on the three main components of mental accounting. The first captures how people perceive and experience outcomes and how they evaluate their decisions. The second concerns the frequency at which accounts are evaluated. Finally, the last component involves the assignment of activities to specific accounts.

1.2a) Mental accounting and outcomes

Concerning the first aspect, Kahneman and Tversky (1984) define three ways to frame outcomes: a minimal account, a topical account and a comprehensive account. Roughly speaking, when people compare two options, a minimal account compares only the difference between the two options, a topical one retains the consequences of possible choices with respect to a contextual "normal" level, and, finally, a comprehensive account incorporates all the other useful factors to choose between the two options. Psychological studies show that mental accounting is topical and the following experiment (Tversky and Kahneman, 1981) gives an illustration of these phenomena:

Imagine that your are about purchase a jacket for ($125)[$15] and a calculator for ($15)[$125]. The calculator salesman informs you that the calculator you wish to buy is on sale for ($10)[$120] at the other branch of store, located 20 minutes drive away. Would you make the trip to the other store?

Most people answer that they are ready to travel in the parentheses version of the test but this is not the case in the brackets version. This choice describes the use of a topical account. The 5$ savings is compared to the initial price of the product it is associated to. Then, 5$ is important with respect to 15$ and then deserves a travel to the other branch of the store but it is not enough important compared to 125$. As Thaler (1999, p.187) says, in opposition to the classical point of view: "framing does alter choices in the real world because people make decisions piecemeal, influenced by the context of the choice".

In addition, studies of mental accounting (Thaler, 1980, 1985) confirm that people perceive outcomes in terms of a value function defined over gains and losses relative to a reference point (see previous section). In the case of multiple outcomes, Thaler (1985) assumes that

[5] For more details, see Thaler (1999).

people code outcomes to maximize their happiness (hedonic editing hypothesis). More precisely, given the shape of the value function, principles of hedonic framing are:

- Segregate gains and integrate losses (due to the shape of the value function);
- Integrate small losses with large gains and segregate small gains from large losses.

Seongyon Lim (2006) tests the first assumption on individual investor's behaviour and finds results consistent with the hedonic editing hypothesis. More precisely, using a trading record of individual investors at a large discount brokerage house from 1991 to 1996, the author shows that, on the one hand, investors are more likely to bundle sales of losers on the same days[6] and, on the other hand, when a winner stock is sold, selling another winner stock on the same day is less likely.

Another component of an accounting system is the decision to close or to leave open an account. In a financial context, according to mental accounting, investors will be reluctant to sell securities that have declined in value. This is due to the fact that closing an account at a loss is painful. In a context where capital losses are tax-deductible, rational analysis predicts that selling loser stocks is likely whereas mental accounting favors the selling of winning stocks (Shefrin and Statman, 1985). As we will see in section 2.1, the fact that individual investors hold on to losers too long is now well documented.

1.2b) Time and mental accounting

As we said before, a second aspect of mental accounting concerns the frequency at which accounts are evaluated. This point could, for example, concern whether a series of decisions are made separately or grouped at one time (called "choice bracketing" by Read, Lowenstein and Rabin, 1998). Simonson (1990) suggests that when people have to make several choices at the same time, they tend to use a naïve diversification rule, whereas this is not observed when they have to make sequential decisions. This behaviour has important financial implications because it generates a "diversification bias" (Read and Lowenstein, 1995).

Benartzi and Thaler (2001) provide a good illustration of this point. These authors ask employees of the University of California to share a part of their wealth between two funds, labeled Fund A and Fund B, based on a year-by-year performance chart of the funds.

[6] For other tests of these principles, see for example, Thaler and Johnson, 1990.

- Experiment A: 100% stocks (Fund A) and 100% bonds (Fund B),
- Experiment B: 100% stocks (Fund A) and 50% stocks / 50% bonds (Fund B)
- Experiment C: 50% stocks/50% bonds (Fund A) and 100% bonds (Fund B)

In this context, the authors show that people tend to use very simple rules and to divide their contributions across the offered funds equally. It is obvious that the risk level (exposition to the stock market risk) is very different in the three naïve diversification choices and investors seem to neglect this crucial aspect.

Another important point is the framing used by people to evaluate gains and losses. As we saw before, the decision to close an account at a loss is very painful and consequently people tend to take more risk before the closing date to avoid this pain (Kahneman and Tversky, 1984). The choice of framing has many consequences. For example, Camerer *et al*. (1997) show that the daily framing selected by a majority of cab-drivers in New-York reduces the profit of their business. In the financial context, the january effect can be due to an annual framing by investors and, in the same vein, Benartzi and Thaler (1995) demonstrate that the equity premium puzzle can be solved with narrow framing (see section 3.1).

1.2c) Mental accounting and budgeting

The last aspect of mental accounting we want to point out is the categorization or labeling of the accounts. Money is generally ranked at different levels: expenditures are allocated to budgets (housing, food, etc.), wealth is allocated to specific accounts and incomes are divided into categories (regular, exceptional, for example). The main characteristic of these accounts is that they are not fungible. Briefly speaking, euros in some category have not the same properties than euros in another category. It is due to the location of funds in different mental accounts.

Based on this argument, Shefrin and Thaler (1988) proposed a hierarchy of wealth accounts. More precisely, these authors base rankings on how tempting it is for a household to spend the money. Then, the first class of assets is the “current asset” category (cash on hand, for example) and the marginal propensity to spend a dollar is here nearly 1. Conversely, the last class contains “future income” accounts (retirement savings, for example) and the propensity to spend a dollar in this account is close to zero. Concerning the source of income, O’Curry (1997) shows that the nature of funds (serious or frivolous) has an impact on the nature of the expenditures. In other words, serious funds are allocated to serious expenditures. In finance, this “non fungibility” across accounts gives a good explanation to the dividend puzzle (Shefrin and Statman, 1984). In a context where dividends are taxed at a higher rate than capital gains, no firm should pay dividends and all firms should prefer share repurchases. In the mental accounting context, investors like dividends because they can spend this amount and leave the principal safe. The rule used by investors to spend money is easier to apply in this context than when firms make share repurchases.

Based on the same arguments, Shefrin and Statman (2000) develop a behavioural portfolio theory where investors think of their portfolio as a pyramid of assets. Then, the first category is built to preserve wealth and contains assets like money market mutual funds. At the opposite (the top of the pyramid) the last category is built to preserve the hope to become rich and contains high risk securities like options or highly volatile stocks. Note that this approach can lead to a portfolio composition which is very different than the one predicted by the traditional view[7].

2 / Some puzzles addressed by prospect-theory and mental accounting.

As all important features of prospect theory and mental accounting were presented in the first part of the paper, we detail now some examples of investors’ behavioural “mistakes” for which these two concepts play a role. More precisely, we investigate two well documented phenomena, respectively the disposition effect and the non-participation / under-diversification puzzle. For each of them, we give empirical and experimental evidence and show how classical and behavioural justifications may help to understand their wide spread on financial markets.

2.1 / The disposition effect

“It was a phenomenon that I found again and again and that seems to be an innate part behaviour: inertia against changing a losing position, and more specifically inertia when faced with losses coming from unexpected corners”

Richard Bookstaber
A demon of our own design
Wiley, 2007, p 74.

[7] For more details, see for example, Broihanne, Merli and Roger (2004, 2006)

The disposition effect is the tendency of investors to sell winning stocks too early and to hold on to losers too long. It was first labeled and analyzed by Shefrin and Statman (1985). An investor prone to the disposition effect will be called a *disposition investor* in the following.

2.1a) Theoretical justifications

Many explanations of the disposition effect have been proposed in the literature. The first one, and probably the most intuitive, is based on an irrational belief in mean reversion of stock prices. It may be linked to the gambler's fallacy. After a number of successive occurrences of heads in a coin toss, the gambler starts to believe that tail is due. Concerning stock prices, this may be translated in the following way. After a price increase, the disposition investor starts to believe that the probability of a price drop in the next period is higher than the one of another price increase. He is then more prone to sell the stock. This interpretation can be found in Shu *et al.* (2005). It is also illustrated in the experiment of Weber and Camerer (1998) which is designed to mitigate the disposition effect (details are provided in section 2.1c). Even when participants are informed that successive returns are independent random variables, the disposition effect is observed. On the aggregate, 51 % of sales concern winning stocks but only 39 % concern losing stocks.

An alternative explanation of the disposition effect is proposed by psychologists who work on the theory of entrapment or escalation of commitment (Staw (1976), Brockner (1992)). This literature tries to understand why and under which conditions people stick to or reinforce a failing course of action. Entrapment appears in dynamic settings when agents face negative feedbacks about past decisions and have to choose between stopping or pursuing a course of action. In an investment context, the question is to know if it is better to keep a losing investment, to increase the stake (to break even), or to sell the losers and choose other stocks to invest in (Zuchel, 2001).

Weber and Zuchel (2005) propose an interesting experimental study to distinguish between the disposition effect and the competing assumption, the *house money effect* (Thaler and Johnson, 1990), which leads to increase risk taking after gains and to reduce it after losses. Their study reveals that in the context of a two-period portfolio choice, participants increase their stake in the risky asset at the second period after a loss, an observation consistent with the escalation of commitment hypothesis. However, when they frame the problem as two successive and independent lottery choices (involving the same monetary amounts), participants exhibit the house money effect, investing more in the risky lottery after a gain than after a loss. It then seems that framing effects may also be important for decision makers. Presenting a problem as a multiperiod portfolio choice or as participation to successive plays of a game of chance can lead to significantly different answers.

Selling winning stocks too early and keeping losing stocks too long can also refer to preferences including the idea that investors seek pride and want to avoid regret when taking investment decisions. This interpretation already appeared in Shefrin and Statman (1985) and has recently been developed by Muermann and Volkman (2006). The authors argue that loss aversion alone cannot explain the disposition effect as shown by Barberis and Xiong (2006) and Hens and Vlcek (2005) and they include the anticipation of regret and pride in a dynamic portfolio choice setting. This approach has recently been supported by experimental evidence (O'Curry Fogel *et al.* 2006).

However, the most common explanation of the disposition effect in the economic literature is based on the assumption of prospect theory preferences and, more precisely, on the S-shaped valuation function assumed in this model. When a stock price is higher than the buying price (or more generally than the reference price), the investor is in the concave part of his valuation function, as depicted in figure 1. He is then risk averse and may sell the stock if the expected return is perceived as too low. After a price drop, the investor is in the convex part and keeps the stock because he has become risk seeking. Following Shefrin and Statman (1985), a number of authors[8] have used this argument to justify the existence of disposition investors. In other words, when agents are risk-averse over gains and risk lovers over losses, they prefer to realize paper gains and to keep paper losses.

Recently, Barberis and Xiong (2006) (see also Hens and Vlcek (2005)) have analyzed more deeply this explanation and obtain controversial results. Their paper shows that the disposition effect is observed for some values of the expected stock return and the horizon of the investor, but they also find the opposite effect for other reasonable values of these parameters. The intuition of their result is that agents prone to sell their stocks after a gain and to keep them after a loss would not have bought the stock in the first place. In a continuous-time model, Kyle *et al.* (2006) also show that, depending on the risk-return characteristics of the stocks, the disposition effect or the opposite can arise. Roughly speaking, investors exhibit a

[8] For example Odean (1998) and Weber and Camerer (1998)

propensity to hold on to losers and to sell winners when the Sharpe ratio is considered as too low.

The results of these diverse approaches show that there is no consensus about the theoretical explanation of the disposition effect. However, there is a strong empirical and experimental evidence about the role of the disposition effect in investment decisions.

2.1b) The empirical evidence

The early studies, following Shefrin and Statman (1985), analyzed the abnormal trading volumes on stocks that had risen in price over previous periods. Lakoniskok and Smidt (1986) found much more volume for winners on NYSE and Amex stocks and Ferris *et al.* (1988) showed on 30 U.S stocks that current volume is negatively correlated with volume on the preceding days, when the price has risen. The reverse correlation appears for stocks whose prices have dropped on the preceding days. As these studies concern aggregate volume, they do not reveal anything about the individual decision process of traders.

Concerning the behaviour of individual investors, the reference study is Odean (1998) who analyzed 10 000 individual accounts at a large discount broker between 1987 and 1993. The two main results of Odean are the following:

a. The proportion of realized gains is significantly larger than the proportion of realized losses, except in December (essentially for tax reasons).

b. The winning stocks (which were sold) perform better, in subsequent periods, than the losing stocks (which were kept).

The author calculates the two following ratios:

$$PGR = \frac{\text{Realized gains}}{\text{Realized gains+Paper gains}}$$

$$PLR = \frac{\text{Realized losses}}{\text{Realized losses+Paper losses}}$$

where PGR (PLR) denotes the proportion of realized gains (losses).

Table 4 reports the results[9].

Table 4 around here

[9] It is the table I, p 1783 in Odean's paper.

We observe that the proportion of realized losses is far lower than the proportion of realized gains. The difference of the two proportions is strongly significant. However, in December, realized losses are much higher because investors liquidate losing positions to cut taxes.

An elementary interpretation of this result is that a paper loss is perceived as less painful than a realized loss and/or that a realized gain generates more utility than a paper gain. The other usual interpretations are that investors (erroneously) believe that stock prices revert to the mean; they then realize gains and retain losing investments to wait for recovering. Selling the winners may also be justified to rebalance portfolios or to avoid high transactions costs on low-price stocks. Odean (1998) finds that the disposition effect is persistent even when controlling for these two arguments. Lehenkari and Pertunnen (2004) analyze individual trades on the Finnish market and also find that capital losses reduce the selling propensity of investors; however, they don't find the opposite effect for capital gains. Brown *et al.* (2003) replicated Odean's results on the Australian market and Chen, Kim, Nofsinger, and Rui (2004) on the Chinese market.

Concerning professional traders, Garvey and Murphy (2004) analyzed the behaviour of a proprietary stock-trading team (15 traders) specialized on NASDAQ stocks. This team generated $1.4 million in intraday trading profits for a 3 month period (8 March-13 June 2000), in a downward-trending market. The members of such teams obviously work with a very short horizon (a few minutes) and their trades are not motivated by diversification needs or capital constraints. The activity of each trader in the team usually focuses on one or two stocks. Garvey and Murphy show that the mean duration of a losing roundtrip is 268 seconds and the duration of a winning roundtrip is only 166 seconds. They also show that closing profitable positions early and holding losing positions longer is not optimal because it reduces the global profitability of the team under scrutiny. Shapira and Venezia (2001) also observe the disposition effect for professional and individual investors on the Israeli market. Genesove and Mayer (2001) illustrate the differences in the behaviour of buyers and sellers on the housing market, leading them to conclude to the existence of a disposition effect.

Coval and Shumway (2005), Frino *et al.* (2005) and Locke and Mann (2003) obtain the same kind of results on different futures markets. In the same vein, Jordan and Diltz (2004) show that a large majority of day traders hold losing trades longer than profitable trades. Shu *et al.* (2005) and Barber *et al.* (2007) show that Taiwanese investors are much more reluctant to realize their losses than U.S investors. However, Shu *et al.* (2005) observe the reverse effect on low-return, high-price stocks. They interpret their findings by saying that Taiwanese traders exhibit a stronger belief in mean reversion than U.S traders.

2.1c) Experimental evidence

The reference experimental paper is Weber and Camerer (1998) (see also Chui (2001)). As mentioned before, these authors proposed to the participants to build a portfolio by choosing in a set of six "artificial" stocks, divided into three categories. Two stocks have a positive (negative, zero) expected return. The price changes are exogenous and i.i.d so that players can infer (after a number of periods) the stocks with an upward (downward) trend or no trend at all. Beyond the abovementioned result of 51 % of sales of winning stocks and only 39 %, of losing stocks, two other interesting points are worth to be mentioned. As participants are informed that successive price changes are i.i.d, they cannot rationally believe in mean reversion. As they learn about the trend after each price change, one could have expected a behaviour contradicting the disposition effect, that is participants should keep winning stocks and sell losing stocks.

A second experiment is presented by Weber and Camerer (1998) in which stocks are automatically sold at the end of each of the 14 periods of the game, but participants have the possibility to buy back the stocks immediately, without bearing transaction costs. The authors observe that the disposition effect is sharply reduced when this automatic selling procedure is used. Players are not so eager to buy back the losing stocks. This observation may be related to self-control problems. When agents have to decide themselves, they irrationally believe that stock prices will bounce back after a price decrease, even if they are informed that successive price changes are independent random variables. Roughly speaking, they are subject to a kind of gambler's fallacy. After losing periods, they start to believe that "luck" is due in the next draws and they have not sufficient willpower to take the selling decision.

2.2 / Non-participation and under-diversification

According to narrow framing, the typical economic agent does not maximize a utility function defined only over total wealth (see section 1.1). This behavioural feature plays an important role in financial markets where investors are supposed, according to EUT, to evaluate a new investment by merging it with pre-existing risks they already hold and check if the combination is attractive. If the new investment is independent of the agent's other risks (labor income risk, house price risk…), in the absence of narrow framing, all investors should consider it is attractive in terms of diversification benefits, as soon as the expected return is sufficient.

However, a number of studies document a general phenomenon of under-diversification (see for example, Polkovnichenko (2005)). Moreover, other empirical puzzles like stock market non-participation and the home bias (Coval and Moskowitz (2001), Grinblatt and Keloharju (2001), Huberman (2001)) can be addressed by incorporating narrow framing in traditional investment decision models. Actually, many households are reluctant to allocate money to the stock market and if they do, they may adopt an erroneous diversification strategy where they hold only a small number of stocks or ignore correlations among them (Kroll and Levy (1992)). They also may prefer stocks from certain categories or styles.

2.2a / Theoretical justifications

Traditional explanations of these phenomena rely on the existence of market frictions (transaction costs, search costs and costly information, investors' inability to buy in round lots) that may prevent investors from diversifying appropriately (Nieuwerburgh and Veldkamp (2004)). Alternative approaches argue that a correlation between background risk of non stockholders and stock market returns explains non participation (Vissing-Jorgensen (2002)) or that background risk simply reduces the attractiveness of equities.

Another stream of research proposes that stock-market participation is influenced by social interaction (Hong, Kubik and Stein (2004)) and financial awareness (Guiso and Jappelli (2005)).

Finally, a number of explanations of households' investment choices rely on non-EUT preferences. These approaches make useful predictions for portfolio choice and asset pricing, that is the reason why we choose to present them in details.

Barberis and Huang (2006) propose an asset allocation model based on investors' utility functions under narrow framing and loss-aversion assumptions. This model is close to the one developed in Barberis, Huang and Santos (2001) but the specification of preferences is modified in order to investigate the implications of narrow framing on portfolio choice.

In order to present the model of Barberis and Huang (2006), we briefly summarize a simplified version of the one given in Barberis, Huang and Santos (2001).

Date t agent's wealth and consumption are denoted (W_t, C_t). The difference $W_t - C_t$ is invested in three assets: a risk-free asset (*f*), a stock market index (*S*), and a non-financial asset (*N*), taking into account, for example, human capital and/or housing wealth. $R_{f,t}$, $R_{S,t}$ and $R_{N,t}$ stand for the gross returns of the three assets. The corresponding shares of wealth invested in these assets are denoted as $1-\theta_{S,t}-\theta_{N,t}$, $\theta_{S,t}$ and $\theta_{N,t}$. The evolution of the agent's wealth is then defined by:

$$W_{t+1} = (W_t - C_t)\left[\theta_{S,t}R_{S,t+1} + \theta_{N,t}R_{N,t+1} + (1-\theta_{S,t}-\theta_{N,t})R_{f,t}\right] \tag{2}$$

The agents maximize the following utility function:

$$E_0 \sum_{t=0}^{+\infty} \left[\beta^t \frac{C_t^{1-\gamma}}{1-\gamma} + b_0 \beta^{t+1} \overline{C}_t^{-\gamma} \overline{v}(G_{S,t+1}) \right] \tag{3}$$

In the expression between brackets, the first term is the usual power utility function of the consumption-based model (Lucas (1978), Breeden (1979)) where β is the discount factor and γ defines the risk aversion of the agent. The behavioural component corresponds to the second term. $\overline{C}_t$ is the aggregate per capita consumption and $\overline{v}(G_{S,t+1})$ is defined by[10] :

$$\begin{aligned} G_{S,t+1} &= \theta_{S,t}(W_t - C_t)(R_{S,t+1} - R_{f,t}) \\ \overline{v}(x) &= \begin{cases} x & \text{if } x \geq 0 \\ \lambda x & \text{if } x < 0 \end{cases} \end{aligned} \tag{4}$$

where $\lambda > 1$ is the coefficient of loss aversion. $\overline{v}(G_{S,t+1})$ measures the utility coming from the variation of wealth invested in the stock market. This formulation means implicitly that the reference wealth level is the date-*t* wealth capitalized at the risk-free rate. It is based on a simplified version of prospect theory in which the valuation function is piecewise linear (α=β=1) and the probability distribution of returns is not distorted.

The first-order conditions of this optimization program are the following:

$$\begin{aligned} &\beta R_{f,t} E_t \left[\left(\frac{\overline{C}_{t+1}}{\overline{C}_t} \right)^{-\gamma} \right] = 1 \\ &\beta E_t \left[R_{S,t+1} \left(\frac{\overline{C}_{t+1}}{\overline{C}_t} \right)^{-\gamma} \right] + b_0 \beta E_t \left(\overline{v}(R_{S,t+1} - 1) \right) = 1 \end{aligned} \tag{5}$$

[10] $R_{f,t}$ is the return of the risk-free asset between *t* and *t* + 1 and $R_{S,t+1}$ is the return of the index within the same period.

When $b_0 = 0$, we recognize the usual first-order conditions of the consumption-based model. Narrow framing corresponds to $b_0 > 0$. It introduces an extra-term in the second condition. If the investor consumes less today to invest in the stock market, he is exposed to a price drop, meaning direct disutility coming from the sole variation of financial wealth.

Barberis and Huang (2006) use this model to investigate the implications of narrow framing on portfolio choice. This is achieved by using a non-expected utility formulation known as recursive utility[11] and extending this formulation to incorporate narrow framing with parameter b_0. The authors still assume that three assets are available on the market: a risk-free asset, a stock index and a non financial asset. The agent's problem in this framework is to maximize the utility given by:

$$V_t = W(C_t, \mu(V_{t+1} / I_t) + b_0 E_t(\overline{v}(G_{S,t+1}))) \qquad (6)$$

where,

$$W(C, y) = ((1-\beta)C^\rho + \beta\mu^\rho)^{1/\rho}, 0 < \beta < 1, 0 \neq \rho < 1 \qquad (7)$$

$$\mu(z) = (E(z^{1-\gamma}))^{1/1-\gamma} \qquad (8)$$

$$G_{S,t+1} = \theta_{S,t}(W_t - C_t)(R_{S,t+1} - R_{f,t}) \qquad (9)$$

$$\overline{v}(x) = \begin{cases} x & \text{if } x \geq 0 \\ \lambda x & \phantom{\text{if }} x < 0 \end{cases} \qquad (10)$$

In equation (7), ρ controls the elasticity of intertemporal substitution.

Barberis, Huang and Thaler (2006) show that these preferences can solve the non-participation puzzle for reasonable parameter values. The idea behind their paper is to build preference specifications that explain both the rejection of a small (S), independent, gamble G_S and the acceptance of a large (L), independent gamble G_L for reasonable wealth levels. The authors give an example which illustrates their approach: as a high level of risk aversion for any kind of utility function results in the rejection of $G_S = (550, 1/2; -500, 1/2)$, it is difficult to find a risk aversion parameter for which the agent accepts at the same time $G_L = (20\,000\,000, 1/2; -10\,000, 1/2)$. Moreover, Barberis, Huang and Thaler add another

[11] Formally, utility at time *t* is given by $V_t = W(C_t, \mu(V_{t+1} / I_t))$, which allows aggregation of current consumption with the certainty equivalent of future utility given current information to give current utility (Epstein and Zin (1989)).

condition on the preference specification: it should explain the G_S rejection and the G_L acceptance whenever they are immediate or delayed. Actually, when applied to the financial market, this approach can explain the non-participation puzzle by considering that agents do not merge the financial asset risk, which is delayed, with the other pre-existing risks they are facing. Besides, in the case of portfolio choice, the "gambles" under consideration are not perfectly independent.

The agent's portfolio problem is to determine the fraction θ_S of his wealth to be invested in the stock market in a setting where the returns of the three assets are R_f, $\log R_{N,t+1} = g_N + \sigma_N \varepsilon_{N,t+1}$ for the non financial asset (pre-existing risk), and $\log R_{S,t+1} = g_S + \sigma_S \varepsilon_{S,t+1}$ for the stock, with $\begin{pmatrix} \varepsilon_{N,t} \\ \varepsilon_{S,t} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \omega \\ \omega & 1 \end{pmatrix}\right)$, i.i.d. over time.

Barberis, Huang and Thaler solve this problem for three preference specifications: (i) the power utility form (without narrow framing), $E_0 \sum_{t=0}^{+\infty} \left[\beta^t \frac{C_t^{1-\gamma}}{1-\gamma} \right]$; (ii) the recursive utility with first-order risk averse certainty equivalent (FORA, (6) without narrow framing) ; (iii) the recursive utility with first-order risk averse certainty equivalent and narrow framing of stock market risk (NF, see equation (7) to (10)). They compute the range of preference parameters for which $\theta_S \leq 0$ (non participation) with historical values ($g_S = 6\%, \sigma_S = 20\%, g_N = 4\%, \sigma_S = 3\%, \theta_N = 75\%, R_f = 1{,}02, \omega = 0{,}1$). The values of the other parameters are $\beta = 0{,}9; \rho = -1; b_0 = 0{,}1$.

Table 4 gives the parameter values obtained for the three utility functions.

Parameter values (γ, λ)	Power	FORA	NF
$\theta_S \leq 0$ (non participation)	$\gamma \geq 137$	$\gamma \geq 80$	$\lambda > 2{,}5$
Acceptation of G_L	No, rejection	$\lambda < 60$ but $\gamma = 0$	All values

Table 4: Parameter values (γ, λ)

The recursive utility with first-order risk averse certainty equivalent and narrow framing of stock market risk is the one allowing non participation while still predicting acceptance of a large gamble. For example, with a loss aversion parameter of 3, the sensitivity to losses is sufficient to make the stock market unattractive when evaluated in isolation, but not enough to reject a large gamble.

2.2b / Empirical evidence

Dimmock (2005) uses survey data from the Center Savings Survey (now called DNB Household Survey) in the Netherlands to measure household's loss-aversion coefficient and to test its impact on market participation and allocation to equities. As CSS contains series of questions designed to measure psychological concepts, Dimmock collects answers to two additional questions based on those used in Thaler (1981) to measure loss-aversion. These two questions ask for the rate of time preference over one year but they are not framed identically: the first one asks for an amount required to defer a given amount in one year whereas the second one asks for an immediate amount to speed-up receipt of the given amount. For example, if we consider the mean response of the sample, it appears that households are indifferent between 1000 today and 1268 in one year but also indifferent between 952 today and 1000 in a year, or by rescaling, between 1000 today and 1050 in a year. As this is consistent with loss-aversion, Dimmock uses PT with a discount factor of utility $\phi(t)$ to derive the value of λ_i for each individual *i* in the following way[12]:

$$\begin{cases} -\lambda_i.(-1000)^\gamma + \phi(t).1268^\gamma = 0 \\ \\ 952^\gamma - \lambda_i.\phi(t).(-1000)^\gamma = 0 \end{cases} \Leftrightarrow \begin{cases} \dfrac{\phi(t)^{1/\gamma}}{\lambda_i^{1/\gamma}} = \dfrac{-1000}{1268} \\ \\ \phi(t)^{1/\gamma}.\lambda_i^{1/\gamma} = \dfrac{952}{-1000} \end{cases} \Leftrightarrow \lambda_i^{2/\gamma} = 1,21$$

After controlling for risk aversion, credit constraints and other individual effects[13], Dimmock finds that individuals with greater loss-aversion are less likely to participate in the stock market, and if they do so, to allocate a lower part of wealth to risky assets. These effects are economically significant, suggesting that in the absence of loss-aversion, households would be highly likely to participate and allocate much of their wealth to equity.

Kumar and Lim (2004) test the link between narrow framing and the disposition effect. They identify "narrow framing investors" as those who tend to execute just one trade on any given day and find that these investors exhibit a higher disposition effect and hold more undiversified portfolios. Liu and Wang (2006) apply the same methodology to study

[12] The example is derived by taking the mean response of the sample as the response of any individual.

[13] These include age and time effect, income, education, expectation of future labor income, interest in finance and dynamic inconsistency.

investors’ trading behaviour in the Taïwan derivatives market. They distinguish different groups of traders and show that sophisticated or experienced traders[14] display a lower degree of narrow framing.

Goetzmann and Kumar (2005) analyze the diversification choices of 62 387 individual investors who trade stocks at a large US discount brokerage house[15] during the period 1991-1996. In this database, an average investor holds a 4 stock portfolio and the extent of under-diversification is examined by other measures that accurately exploit the variance-covariance structure of investors’ portfolios. As other studies have already given evidence of an under-diversification behaviour of US household portfolios, here diversification choices are analyzed over time along with additional potential determinants. Goetzmann and Kumar show that personal characteristics of investors are at stake: younger and less wealthy investors exhibit greater under-diversification. Moreover, the extent of under-diversification is more severe for investors who hold only retirement accounts. A low level of investors’ information and sophistication, or a high tendency to be subject to behavioural biases (over-confidence, local bias, trend following) are also observed with under-diversification, whereas other traditional factors (small portfolio size, transaction and search costs) do not influence investors’ choices.

3) Prospect theory, mental accounting and asset prices

In this section we investigate how the behavioural mistakes of investors may affect asset prices and returns predictability. In a first part, we show that a famous financial puzzle, e.g. the equity premium puzzle, may find some explanations relying on the loss aversion / narrow framing or the repeated gambles approaches. The second part of the section looks at some findings on the cross-section of returns (momentum effects, post-earning announcement drift) and demonstrates the impact of prospect theory and mental accounting on these findings.

3.1 / The equity premium puzzle

[14] Sophisticated traders are defined as options traders who execute combination orders and futures trades. Experience of traders is measured by the variance of purchase dollar amounts, the number of purchases and the number of different options purchased, divided by the number of investors by trading period.

[15] This dataset is shown to be highly representative of US stockholders by comparison with the Federal Reserve Survey of Consumer Finance of 1992 and 1995.

The *equity premium puzzle* comes from the observation that, on US markets, the return on stocks has been about 6% higher than the one on T-bills, on a yearly basis, over the twentieth century. Siegel and Thaler (1997) summarize the point in the following way:

"Suppose your great grandmother had some money lying around at the end of 1925 and, with rational expectations, anticipated your birth and decided to bequeath you $1000. Naturally, since you weren't born yet, she invested the money, and being worried about the speculative boom in stocks going on at the time, she put the money in Treasury bills, where it remained until December 31, 1995. On that date it was worth $12,720. Imagine, instead that she had invested the money in a (value-weighted) portfolio of stocks, you would now have $842,000, or 66 times as much money."

Mehra and Prescott (1985) were the first to analyze this phenomenon in the framework of the standard consumption-based model *à la* Lucas (1978). They labelled the question of the equity premium a *puzzle* because they were not able to explain it using the standard model, with reasonable values for the parameters. In fact, they found that a risk aversion coefficient greater than 30 is needed to explain the equity premium when the usual values lie between 1 and 10.

Hundred of papers have been published since then. Moreover, the equity premium puzzle is associated with at least three other puzzling observations: the low and stable level of the real risk-free rate, the smoothness of the consumption growth and the low correlation between consumption growth and stock returns.

A survey on these subjects would deserve a complete paper, if not an entire book. For a recent comprehensive treatment, we refer to the *Handbook of Investments: the Equity Risk Premium* edited by R. Mehra (2007)[16]. In the present paper, we will only concentrate on the main behavioural explanations of the equity premium puzzle, respectively loss aversion and the repeated gambles approach.

Loss aversion is one of the essential features of prospect theory (see section 1.1) and departs from the expected utility model for at least two reasons. First, defining loss aversion needs to know what is a loss or, in other words, what is the reference point with respect to which gains and losses are defined. Second, loss aversion induces a kink in the valuation function to translate the idea that investors are more sensitive to losses than to gains.

[16] The contents of this forthcoming book can be seen at the following address: http://www.elsevier.com/wps/find/bookdescription.cws_home/707603/description

Narrow framing[17] appears in several contexts. In the standard EU model, agents value the expected utility over their global wealth. On the contrary, narrow framing means in this case that investors value the purchase of a risky asset in isolation. Utility is evaluated directly with respect to the possible price variations of this specific financial asset.

Tversky and Kahneman (1981) first provided experimental evidence of narrow framing by asking 150 subjects to examine the two following choices and then to indicate the option they prefer:

I) *Choose between:*

A. a sure gain of $240

B. 25% chance to gain $1000 and 75% chance to gain nothing

II) *Choose between:*

C. a sure loss of $750

D. 75% chance to lose $1000 and 25% chance to lose nothing.

The authors report that 84% of subjects chose A and 87% chose D. In particular, 73% of subjects chose the combination A-D, which is surprising, given that this choice is dominated by the combination B-C. Instead of focusing on the outcome that determines their final wealth (the combined outcome of decisions I and II), subjects are focusing on the outcome of each decision separately. Kahneman and Lovallo (1993) also demonstrate that decision makers usually isolate current choices from future opportunities and neglect the connection in terms of future choice opportunities.

Using this observation, Benartzi and Thaler (1995) study the equity premium puzzle by introducing a different type of narrow framing. They consider investors who choose between stocks and bonds and get utility from the variations of their financial wealth only (the portfolio value). As the financial wealth is only a part of global wealth, they implicitly assume a form of narrow framing. They also assume that long-term investors are myopic in the sense that they value their financial wealth at regularly spaced dates[18] and get utility from the variations observed at these dates. They show that an evaluation period of one year allows to explain the high equity premium required by investors. Following Benartzi and Thaler (1995), Gneezy and Potters (1997) and Thaler *et al.* (1997) give strong experimental evidence of the role of evaluation periods on the risk-taking behaviour of agents.

[17] This term was first used by Kahneman and Lovallo (1993)

[18] The delay between two evaluation dates is called the evaluation period.

However, consumption doesn't play any role in the model presented by Benartzi and Thaler since utility only comes from the variations of financial wealth. To remedy this weakness, Barberis *et al.* (2001) propose a utility function mixing the usual consumption model used by Mehra and Prescott (1985) and the variations of financial wealth in the spirit of Benartzi and Thaler.
A simplified version of their model, the one given in Barberis *et al.* (2001), was exposed in section 2.2a. We do not come back on the technical details but the two first order conditions show that investors characterized by these preferences will require a greater equity premium to invest in stocks. The simulations proposed in Barberis *et al.* (2001) show that reasonable values of parameters lead to a sizeable equity premium and a low risk-free rate, compared to the values obtained in the seminal paper of Mehra-Prescott (1985). Moreover, this framework generates stock returns that exhibit a low correlation with consumption, as in the historical data.

Another behavioural explanation of the equity premium puzzle rests on the idea that, on the stock market, the persistence of a high equity premium leads to ask if investors really consider the return on a long-term investment as the sum of independent random variables, then aggregating the successive variations of prices, or if they consider such an investment as a sequence of plays, each being evaluated in isolation. If the second answer turns out to be the right one, it is a strong argument in favour of myopic loss aversion or at least in favour of a myopic behaviour.

A long term investment in the stock market can be thought of as a sequence of repeated gambles. In fact, if successive returns are assumed to be i.i.d random variables, a one-year investment is equivalent to 12 monthly plays of the same game. The interplay between single and repeated gambles has been the subject of an abundant literature which can be traced back to Samuelson (1963). Samuelson proposed to a colleague to bet \$100 on a coin tossing which pays \$300 if heads appears and nothing if the other side shows up. The net profit of a single play is a random variable X defined by:

$$X = \begin{cases} \$200 \text{ with probability } 0.5 \\ -\$100 \text{ with probability } 0.5 \end{cases}$$

Samuelson's colleague declined the offer but announced he was ready to play 100 such bets, then meaning that the repeated gambles seem less risky than a unique bet.

In his paper, Samuelson shows, using a backward induction argument, that his colleague is irrational. In fact, he is expected to reject the last bet since he is not ready to play only one bet. But as he knows that after the 98th bet, he should reject the 99th which has become the last one. Going backward and applying the same rule leads to reject every sequence of bets. Tversky and Bar-Hillel (1983) gave an axiomatic proof of this result. If we denote X_i the profit of the *i*-th toss, $S_i = \sum_{j=1}^{i} X_j$ the cumulated result of the first *i* tosses and W_0 the initial wealth, Tversky and Bar-Hillel assume:

(A1) The single toss is rejected at any wealth level attainable during the game then

$$W_0 \succ W_0 + y + X_1 \text{ for } -10000 \leq y \leq 20000$$

(A2) Dominance

If *Y* is a random variables with values in [- 10,000; 20,000]

$$W_0 + y \succ W_0 + y + X \text{ for each outcome } y \text{ of } Y \Rightarrow W_0 + Y \succ W_0 + Y + X$$

(A3) Transitivity

$$X \succ H \text{ and } H \succ Z \Rightarrow X \succ Z$$

If these three axioms are used after each toss, we get:

$$W_0 \succ W_0 + X_1 \succ W_0 + S_2 \succ .... \succ W_0 + S_n$$

This relationship leads to reject any sequence of bets.

The two last axioms are hard to dispute; only the first one is based on the answer of Samuelson's colleague. Further experimental studies nevertheless show that this answer is not atypical[19]. In an attempt to illustrate the notion of *aggregation of risk*, Kahneman and Lovallo (1993) consider 3 independent gambles defined in the following way:

G1= [(0\$,0.5);(500\$,0.5)]

G2=G3=[(0\$,0.125), (250\$,0.25), (500\$,0.25), (750\$,0.25), (1000\$,0.125)]

Using a utility function $u(x) = x^{0.575}$, they calculate the sum of the certainty equivalents of the three gambles and obtain 300\$. When aggregating the 3 gambles, the certainty equivalent is 433\$. In other words, aggregation largely decreases the risk premium.

The answer of Samuelson's colleague looks sensible to anybody. For a series of 100 bets, the expected gross return is \$5 000 and the probability of ending in a losing position is less than 0.5 %. The sequence of bets then seems very attractive.

[19] See for example Keren and Wagenaar (1987), Keren (1991), Redelmeier and Tversky (1992)

Many studies of this problem have been provided in the framework of the expected utility model[20] but, one more time, we concentrate our analysis on the behavioural approach. Benartzi and Thaler (1999) tested the myopic loss aversion hypothesis in an experimental framework. They proposed the Samuelson's bets to about 160 participants in two sequences. They first ask if people were ready to participate in one bet and in 100 bets. After the participants have answered these two questions, a probability distribution of results was shown to them and they had to decide to participate (or not) in the game. The probability distribution shown was the one corresponding to 100 Samuelson's bets but, obviously, participants were not informed of that.

Table 5 shows the percentages of acceptations for the three versions of the games. The three columns correspond to the sub-samples. The numbers between brackets in the heading of the table is the number of people in each sub-sample.

Table 5 around here

The answers show that the choice of Samuelson's colleague is not the most popular one. It appears that the acceptation rate is much lower in the repeated gamble when participants are not shown the global distribution of results. The participants do not perfectly aggregate risks. Though it can be interpreted as a myopic behaviour, Aloysius (2005) argues that the behaviour of players can be justified by ambiguity aversion. As they are not able to calculate the global distribution of results, they ask for a higher premium to enter the game. This alternative interpretation has some value on financial markets where the assumption of I.I.D returns is only an assumption. Nobody knows if future returns will really be driven by the past probability distribution. Aversion to ambiguity can then play a role in the determination of a high equity premium.

3.2 / PT/MA and return predictability

In the context of mental accounting, interactions between stocks are neglected and each stock in the portfolio is analyzed separately (see section 1.2). Consequently, following the arguments developed in the previous section, a combination of prospect theory (PT) and mental accounting (MA) can impact investment decisions and generate return predictability. In this section, we focus on two salient findings on the cross-section of returns, respectively *the momentum effect* and *the post-earning announcement drift (PEAD).*

[20] See for example Nielsen (1985), Lippman and Mamer (1988), Samuelson (1989), Gollier (1996), Ross (1999) or Pekoz (2002).

The momentum effect can be characterized briefly by the short to medium term persistence in stock returns. It was first documented on US markets (January 1963 / December 1989) by Jegadeesh and Titman (1993). The authors grouped stocks traded on the NYSE into deciles based on their six month prior returns and find that deciles of the larger prior winners outperform deciles of the larger losers by an average of 10% (annual basis), six months after the portfolio formation. This effect is now well documented (for example, Muga and Santamaria, 2007a, 2007b for Spain and Emerging markets, Glaser and Weber, 2003 for Germany) but the reasons for this effect are still highly controversial (see, for example, Avramov and Chordia (2006), Grinblatt and Moskowitz (2004), Lesmond *et al.* (2004)).

In this context, Grinblatt and Han (2005) suggest that the momentum effect can be due to the presence of PT/MA investors in the market. In their approach, PT / MA investors exhibit demand distortions depending on the unrealized profit (aggregate cost basis less market price) they experience on a stock. Roughly speaking, on the one hand if many investors are subject to the disposition effect and are reluctant to realize their losses, the selling pressure for loser stocks is on the average weaker than the one induced by rational investors. Consequently, if demand is not perfectly elastic past losers tend to be overvalued in equilibrium. On the other hand, the tendency of investors to sell winning stocks too early leads to undervaluation of the past winners. More precisely, PT/MA investors underreact to positive news if stocks have large unrealized capital gains and underreact to negative news when stocks exhibit large unrealized capital losses. This behaviour produces a spread between stock prices and fundamental values. If heterogeneity of PT / MA investors leads to reduce over time the spread between aggregate cost basis and market price, this model predicts that stocks with paper gains (undervalued) will have higher average returns than stocks with paper losses (overvalued). Finally, momentum in stock returns is expected as a consequence of the disposition effect. More formally, two types of demand are defined:

Rational Demand : $D_t = 1 + b_t(F_t - P_t)$

PT/MA demand : $D_t^{PT/MA} = 1 + b_t\left[(F_t - P_t) + \eta(F_t - R_t)\right]$

where F_t is the fundamental date-*t* value of the stock (following a random walk), P_t is its market price and R_t its reference price. η measures the relative importance of gains or losses for PT/MA investors and b_t is the slope of the rational component of the demand function. The evolution of the reference price is given in the equation:

$$R_{t+1} = V_t P_t + (1 - V_t) R_t$$

where the updating weight V_t is assumed to be related to the turnover ratio of the stock. In this context, the equilibrium market price is:

$$P_t = wF_t + (1 - w) R_t \text{ where}$$
$$w = \frac{1}{1 + \mu\eta}$$

The market price is therefore an average of the fundamental value and the reference price of the stock. Parameter w captures the degree of underreaction of prices to public information. It depends on the proportion of PT/MA investors μ and on the demand perturbation induced by these investors. Expected returns are finally expressed as :

$$E_t\left[\frac{P_{t+1} - P_t}{P_t}\right] = (1 - w)V_t\left[\frac{P_t - R_t}{P_t}\right] = (1 - w)V_t\left[g_t\right]$$

Where g_t is the date *t* capital gain overhang. This equation suggests that (1) the expected return on the stock is increasing (monotonically) in the marginal investor's percentage of unrealized capital gain, (2) for a fixed-size gain or loss, high current turnover implies a higher expected return.

This last consequence is due to the fact that a current turnover drop decreases the unrealized gain or loss and finally leads to an aggregate demand function which is closer to the rational demand.

This model has been tested empirically on the US market by Goetzmann and Massa (2003). The dataset contains all common shares traded on the NYSE and the AMEX from July 1962 to December 1996. Weekly data are used (1539 weeks) and the estimation of the market cost basis is estimated as:

$$R_t = \sum_{n=1}^{\infty} (V_{t-n} \prod_{\tau=1}^{n-1} [(1 - V_{t-n+\tau})]) P_{t-n}$$

where V_t is the date-*t* turnover ratio in the stock. The price of date *t-n* is then weighted by the probability that a share traded a date *t-n* has not been traded since then. In the regressions, control regressors are prior cumulative returns (Jegadeesh and Titman, 1993, De Bondt and Thaler, 1985), size and volume (Fama and MacBeth, 1973, Lee and Swaminathan, 2000, Gervais *et al.*, 2001) and the main results are the following:

- 59 % of the cross sectional variations of the capital gain variable are explained by differences in past returns, past turnover and firm size.
- Controlling for past returns, low volume winners tend to have larger capital gains and high volume losers tend to experience smaller capital losses.
- When stocks are first sorted by their past one year return and then by their capital gain overhang, average returns of portfolios increase monotonically with capital gains overhang (except in January)
- When capital gains overhang is introduced, results don't exhibit intermediate horizon momentum anymore and a strong positive relation between the capital overhang variable and future returns is measured.

Finally, all the empirical results strongly support the main implications of this approach; momentum could be explained by the presence of investors subject to the disposition effect.

In the same vein, Frazzini (2006) focuses on the impact of the presence of PT/MA investors on the behaviour of stocks after news publications. More precisely, he argues that the disposition effect can generate underreaction to news and, in turn, return predictability and post-earning price drift.

Post-earning price drift was first documented by Bernard and Thomas (1996). These authors group (every quarter from 1974 to 1986) all stocks traded on the NYSE and the AMEX into deciles. Those deciles are based on the magnitude of the surprise in their last earnings announcement (measured relatively to a random walk model of earnings). The main result is that, over the 60-days period following the earning announcement, the deciles of "good surprise" stocks outperforms the deciles of "bad surprise" stocks by an average of 4%. This anomaly is now well documented (see, for example, Chan *et al.* (1996), Collins et Hribar (2000), Nichols and Whalen (2004)).

Remember that PT/MA investors tend to underreact to positive news when trading takes place at large capital gain and tends to underreact to negative news for large capital losses. Then, in the presence of PT/MA investors, when a stock experiences bad news, and decreases in value relative to the purchase price, trades take place at a temporarily inflated price. In this context,

subsequent returns will be lower and bad news tend to be followed by negative price drift. Using symmetrical arguments, good news tend to be followed by positive price drift.
To illustrate this point, suppose that the stock of a firm X is trading at 25 euros and the aggregate cost basis is 30 euros. This means that most holders bought the stock at a price close to 30 euros and that the stock is currently trading at a capital loss. Suppose that a bad news about X is published revealing a consensus of 20 euros. In the absence of friction, the price should fall instantaneously to 20 euros. However, if investors are reluctant to realize the paper loss, they restrict supply and the price will only fall to a value between 25 and 20 euros. Finally, with this inflated price, subsequent returns tend to be lower.
The main consequences of the presence of PT/MA investors are finally that (1) PEAD is larger when news and capital gain have the same sign and (2) the magnitude of PEAD depends on the amount of unrealized gains (losses) experienced by stockholders.
While previous studies use the turnover ratio or transaction volume as a "proxy" for cost basis (Ferris, Haugen, Makhija, 1988, Grinblatt et Han, 2005) Frazzini uses a direct measure of capital gain overhang. Price reference R_t and capital gains overhang g_t are defined as:

$$R_t = \Phi^{-1} \sum_{n=0}^{t} V_{t,t-n} P_{t,t-n} \text{ and } g_t = \frac{P_t - R_t}{P_t}$$

$$\text{where } \Phi = \sum_{n=0}^{t} V_{t,t-n}$$

$V_{t,t-n}$ is the number of shares purchased at time *t-n* and not sold at time *t* and P_t is the stock price at date *t*.
To compute capital gains or losses, mutual funds common stock holdings are used. The data contains end-of-quarter stock holdings for 29 000 mutual funds between January 1980 and December 2003.
First, the results show that mutual funds managers sell a higher proportion of winning stocks than loosing stocks. The disposition effect is important but smaller that the one reported by Odean (1998) for individual investors (see section 2.1). Moreover, controlling for past returns, low volume winners tend to have larger capital gains while high volume losers tend to experience smaller capital losses. To test the main assumption of this paper, a long-short strategy is implemented to capture the underreaction of the market. If good news tend to be followed by positive price drift and bad news tend to be followed by negative drift, an investment strategy in which a long position in good news stocks is offset by a short position

in bad news stocks must yield positive returns. More precisely, returns should be positively linked to the spread in the capital gain overhang between the two sides of the strategy.
When a rolling portfolio approach is used (Jegadeesh and Titman, 1993, Fama, 1998) empirical results largely confirm the last point. For example, for a rolling period of 3 months and for the full sample, a strategy that is long in a portfolio of the top 20% positive news stocks with large paper gain and short in a portfolio of the bottom 20% negative news stocks with large paper losses gives abnormal returns of 2,433% (measured with Fama and French (1993) model). With the same rolling period, a portfolio that consists in buying the top 20% good news in the negative overhang and selling the bottom 20% bad news stocks in the top overhang delivers abnormal returns close to zero.
These points underline the fact that prices quickly react to bad (good) news if stocks are trading at large paper losses (gains) and that the speed of price adjustment is linked to the sign and magnitude of capital overhang and the sign of the surprise.
Finally these results confirm that post-earnings announcement drift should be due to the presence of PT / MA investors on the financial market.

CONCLUSION

In this paper we documented the ability of the behavioural approach, especially prospect theory and mental accounting, to give some new insights on old financial puzzles. As a first part of the paper was devoted to a presentation of these two essential concepts, we showed how they impact investors’ behaviour and, thereafter, asset prices. Investors’ decisions are very sensitive to behavioural biases and we specifically identified some salient financial mistakes for which no consensus exists about their theoretical explanations. Among all of these explanations, we gave an important place to behavioural ones. We concentrated on approaches that incorporate features of prospect theory (especially different attitudes towards risk over gains and losses), and narrow framing. We showed that they explain phenomena like the disposition effect or the non-participation and under-diversification puzzles. Although all these effects are observed at the individual level, they do not disappear at the aggregate market level. Moreover, these investment errors have consequences on asset prices and, more generally, on the cross-section of returns. A second part of the paper was, therefore, devoted to the study of some classical financial puzzles on a behavioural point of view. We presented some recent work that helps to understand the high level of the equity premium when investors’ decisions are driven by a form of narrow framing, e.g. myopic loss aversion. In the same vein, we showed that return predictability can be explained by the presence of investors subject to the disposition effect. Obviously, our review is not exhaustive since the "behavioural world" is expanding rapidly. Nevertheless, we hope that readers will be convinced that introducing modified preferences and taking into account psychological biases can generate added value to economic and financial research.

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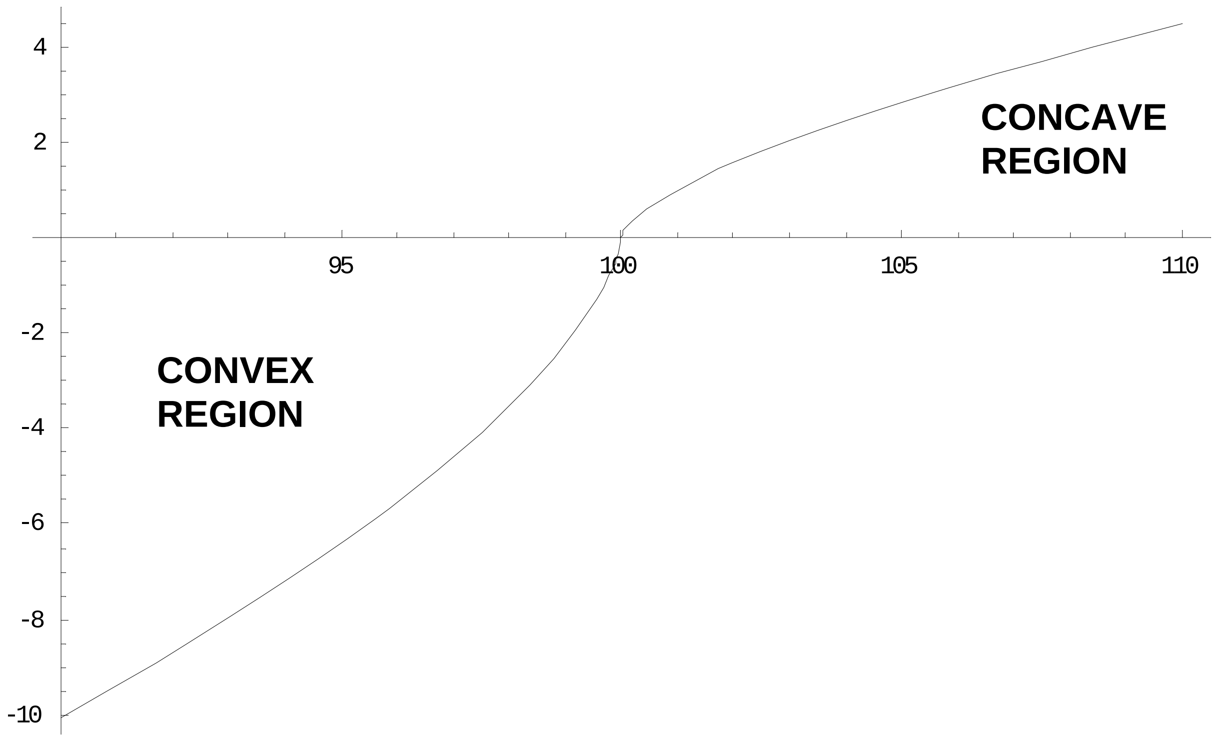

Figure 1:Valuation function of prospect theory : reference level =100

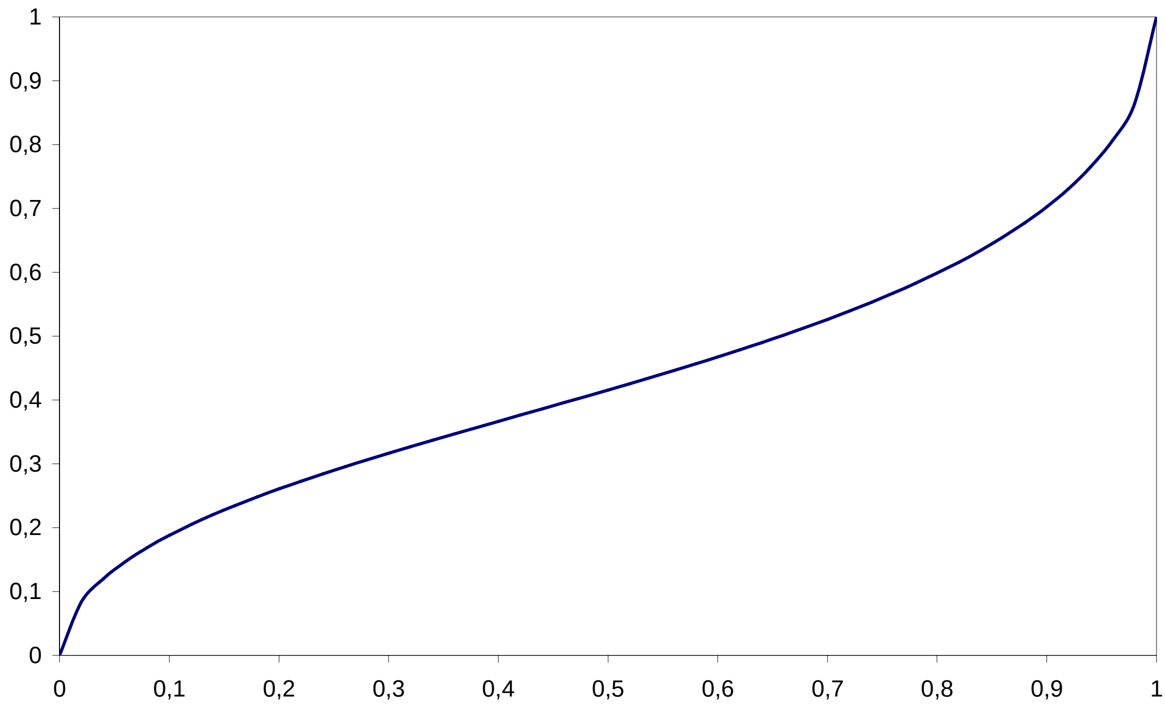

Figure 2: Probability weighting function of Kahneman and Tversky (1979).

Table 4: Percentage of realized losses or gains

Source: Odean (1998)

	Year	December	Jan-Nov
PLR	0.098	0.128	0.094
PGR	0.148	0.108	0.152
PLR – PGR	-0.050	0.02	-0.058
t-statistic	-35	4.3	-38

Table 5

Percentage of acceptations for the single and repeated Samuelson's bets

Source: Benartzi-Thaler (1999)

	Undergraduate students University of California (36)	Visitors to a coffeeshop (62)	MBA students University of Chicago (65)
One bet	77	66	64
Repeated bets (100 times)	50	43	75
Explicit distribution	83	90	86

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